



1994

# Hypermobility and Specific Joint Pathology in Young Competitive Gymnasts

Jonathon M. Weiss  
*University of North Dakota*

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HYPERMOBILITY AND SPECIFIC JOINT PATHOLOGY IN  
YOUNG COMPETITIVE GYMNASTS

By

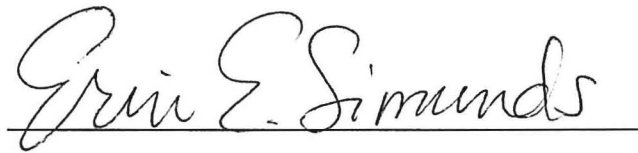
Jonathon M. Weiss  
Bachelor of Science in Physical Therapy  
University of North Dakota, 1993



An Independent Study  
Submitted to the Graduate Faculty of the  
Department of Physical Therapy  
School of Medicine  
University of North Dakota  
in partial fulfillment of the requirements  
for the degree of  
Master of Physical Therapy

Grand Forks, North Dakota  
May  
1994


This Independent Study, submitted by Jonathon M. Weiss in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

A handwritten signature in cursive script, reading "Erin E. Simonds", written over a horizontal line.

(Faculty Preceptor)

A handwritten signature in cursive script, reading "Beverly Johnson", written over a horizontal line.

(Graduate School Advisor)

A handwritten signature in cursive script, reading "Thomas Moore", written over a horizontal line.

(Chairperson of Physical Therapy)

## PERMISSION

Title                    Hypermobility and Specific Joint Pathology in  
                             Young Competitive Gymnasts

Department          Physical Therapy

Degree                Master of Physical Therapy

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Signature Jonathan Weiss

Date 4/19/94



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## ABSTRACT

The purpose of this study was twofold: (1) to study the prevalence of hypermobility in young, competitive gymnasts and (2) to determine if the presence of hypermobility predisposes the athlete to particular joint pathologies. Subjects included 44 female members of the American Gold Gymnastics Club in Fargo, ND. These athletes were divided into three training groups based on age and skill level. All athletes were screened for systemic hypermobility by utilizing the Beighton scale. Lumbar extension, wrist extension, and navicular drop (referred to as range of motion values) were also measured on each subject. Parents and the athletes filled out an injury reporting form, with this information being compared to medical information on hand at the facility. The gymnasts were divided into hypermobile and non-hypermobile divisions within each training group. A t-test was used to determine differences between divisions for number of injuries and range of motion (ROM) values. An ANOVA and subsequent Tukey-B test were used to determine differences between ROM for the three training groups. The youngest training group demonstrated significantly increased left wrist extension, while the oldest group displayed increased lumbar extension and the greatest injury/subject ratio. No relationship was discovered between hypermobility and injury occurrence,

although hypermobile elite gymnasts displayed a significant increase in right wrist extension and a significantly decreased right navicular drop.

## CHAPTER I

### INTRODUCTION

In gymnastics, hypermobility at numerous joints can be a considerable advantage. A wide range of movement in the lumbar spine, hips, shoulders, wrists, fingers, and feet is virtually a prerequisite.<sup>1</sup> By contrast, relative stability is useful at the elbows and knees.<sup>1</sup> There have been a handful of authors who have suggested a relationship between hypermobility and predisposition to musculoskeletal injury.<sup>2,3,4,5</sup> This study will further explore this relationship exclusively as it relates to competitive gymnastics.

In the earliest references to joint laxity, Hippocrates described the Scythians as "so loose jointed that they were unable to draw a bowstring or hurl a javelin."<sup>6</sup> Since the early twentieth century, joint laxity has been found to be associated with orthopedic problems, neurologic diseases, and rheumatic disorders.<sup>2,3,7</sup> The prevalence of hypermobility in the general population is debatable, though studies suggest it is present in 5-7% of school children and in 4-5% of adults.<sup>8</sup> Although there is significant variations in a population, joint hypermobility is generally greater in females,<sup>9</sup> youth, and in blacks.<sup>10</sup>

Grahme, et al reported evidence that systemic joint hypermobility might actually be a mild form of a connective tissue disorder.<sup>11</sup> Generalized joint

laxity can be a symptom of several inherited disorders of connective tissue, including Marfan's syndrome and Ehlers-Danlos syndrome.<sup>12</sup>

Normally, joints are limited from excessive motion by their surrounding soft tissue, primarily the joint capsule. Other supporting structures include adjacent muscles, tendons, and ligaments as well as subcutaneous tissue and skin. At the histological level, the most important component of these tissues is collagen. This rope-like, triple-helical macromolecule is the most common structural protein in the body.<sup>13</sup>

There are eleven types of collagen fibers with Type I being the most abundant. Type I is primarily a component of bones, tendons, and ligaments while Type II collagen is mainly found in hyaline cartilage. Type III collagen accompanies Type I in many connective tissues with muscles and skin containing the highest ratios of Type III to Type I collagen. Type I collagen tends to form thicker fibrils and Type III finer fibrils, although evidence suggests that different types of collagen can make up the same fibril.<sup>14</sup> These fibrils form the fibers of connective tissue. The remaining eight types of collagen are found in minute amounts throughout the body's fascia and soft tissues.

A study by Child<sup>12</sup> that examined skin biopsies from 22 hypermobile female patients demonstrated significantly increased Type III collagen ratios in 14 (64%) of the subjects as compared to age-matched controls. Further electron microscopic study of the skin revealed a markedly decreased proportion of thick collagen fibers and increases in fine collagen fibers, ground

substance, elastin, and fibrocytes in the reticular layer. The authors concluded that the increased systemic ratios of Type III collagen may indicate a genetic error in the biosynthesis of collagen, or premature degradation.<sup>12</sup>

All collagen fibrils are mechanically coiled or "crimped" in vitro. The wavelength of this crimp may vary between individuals due to genetics. This initial wavelength may determine the joint stretching capacity in response to a given force. There is evidence that much of the laxity of connective tissue is inherent to its physical "crimp" characteristics, which may be increased due to a raised systemic ratio of Type III collagen. An increased "crimp" may result in more inherent elasticity, thus demonstrating increased joint laxity.<sup>1</sup> The possibility of genetic error is further supported by data which demonstrates that hypermobility is an inherited gender-dominant trait that primarily affects women.<sup>15</sup>

The connective tissue laxity in hypermobility may be manifested in many areas of the body. Immediately detectable features of generalized hypermobility include scoliosis, genu valgum, recurrent dislocation of the patella, flat feet, excessive passive dorsal-volar wrist motion, excessive lateral joint motion at the proximal interphalangeal joints, effusion in the joint after activity, and premature osteoarthritis.<sup>3,6,8</sup>

The possibility of biomechanical problems leading to injury in a hypermobile gymnast is readily apparent. Gymnastics has been reported to have one of the highest injury rates in women's sport.<sup>16</sup> Injuries in women's



gymnastics are basically caused by repetitive stress or trauma. Stress injuries such as fatigue fractures, muscle strains, and tendinitis result from the repetitive subthreshold stresses placed on bodily structures.<sup>17</sup> Epidemiologically, stress and traumatic injuries may be predisposed by poor biomechanics which may be prevalent with hypermobility.<sup>18</sup>

In studies on gymnastic injuries, sprains and strains are usually considered to be the most common form of injury experienced. The majority of injuries occur while performing floor exercises, balance beam activities, or during a dismount.<sup>16,19-23</sup> Bos and Sol<sup>23</sup> state that the considerable amount of kinetic energy which is absorbed during these maneuvers could be a risk factor. If the joint capsule and supporting structures were compromised, such as in joint hypermobility, the gymnast may be at a particularly greater risk.

The ankle is the most commonly injured area of the body in competitive gymnastics.<sup>20,21</sup> Many ankle injuries develop from overuse.<sup>16</sup> Lysens et al<sup>24</sup> state that extreme flexibility or even laxity of the ligaments can predispose athletes to ankle sprains.<sup>24</sup>

The second most commonly injured area is the knee. Patellofemoral dysfunction is the most often cited cause of knee pain.<sup>16</sup> Landing from vaults can cause excessive stress to the knee joint, with a great risk of injury to the collateral ligaments.<sup>23</sup> In gymnastics, a mild hyperextension of the knee joint may be aesthetically desirable, but extreme hyperextension

can lead to pathology in the posterior knee and a lack of control over the knee joint.<sup>15</sup>

The incidence of elbow injury in gymnastics is rather low, but the reported injuries are very specific including fractures, dislocations, and ulnar nerve compressions.<sup>26</sup> Injuries primarily occur as high impact loads are distributed across the elbow during various maneuvers. On the balance beam, hands are occasionally fixed in a particular position while the forearms undergo torsion. These repetitive rotational forces can injure the distal radial epiphysis since it is the weakest area of the bone.<sup>22</sup> One study demonstrated that two out of forty-one elbow injuries were caused by chronic microtrauma.<sup>26</sup>

Gymnasts consider pain at the dorsal aspect of the wrist as an inherent part of the sport. Most gymnasts complain of wrist pain during compression or with forced extension.<sup>16</sup> Mandelbaum<sup>22</sup> postulates possible causes for this pain include ligamentous tears, tears of the triangular fibrocartilage complex, and secondary chondromalacia of the different articulations of the wrist.

Back problems are more frequently encountered in gymnastics than in any other school sport.<sup>21,27</sup> A study of Italian Olympic athletes revealed that 42 of 132 gymnasts (32%) demonstrated a spondylolysis and 12 (9%) showed a spondylolisthesis.<sup>28</sup> The high incidence of back pain may be caused by a variety of conditions ranging from hyperlordotic postures to vertebral body fractures and disorder of the intervertebral disc. Back pain appears to result from either a single, traumatic episode or cumulative microtrauma.<sup>29</sup>

Very little information has been published concerning the relationship between joint hypermobility and injury susceptibility in sport. In a study of 139 professional football players, Nicholas<sup>4</sup> discovered that 28 out of 39 "loose" athletes (72%) experienced a rupture of a knee ligament, while only 9% of "tight" athletes sustained a similar injury.

Klemp and Learmouth<sup>30</sup> measured 47 professional ballet dancers for hypermobility and concluded that ballet dancers are not more hypermobile than a control group when the factor of forward flexion of the trunk with palms resting on the floor was eliminated. This maneuver may be attributed to training and not genetic origin. In a four-year follow-up to this study, it was demonstrated that there was a significantly higher percentage of hypermobile dancers among those continuing to perform when compared to those who had stopped. Since it was more common for the hypermobile dancer to have a long career, the authors concluded that it may be an advantage for an individual who embarks on a career in dancing to be hypermobile.<sup>31</sup>

Kirby et al<sup>32</sup> examined 60 competitive female gymnasts and 35 age-matched nonathletic controls for musculoskeletal symptoms and flexibility. A significantly greater number of gymnasts had musculoskeletal symptoms (pain, swelling, tenderness, etc.) in the wrist, low back, hip, shin, and foot regions than did the controls. Gymnasts also exhibited a greater number of symptomatic regions per subject (6.17) than did controls (2.25). Gymnasts demonstrated increased shoulder flexion and horizontal abduction, lumbar

flexion, hip extension, and toe-touching ability. Controls surpassed gymnasts only in the extent of elbow supination. There were no significant differences in lumbar, knee, or elbow extension. Gymnasts with low back pain had greater toe-touching ability, and therefore were more flexible, than those without symptoms. These researchers were not able to establish a clear link between flexibility and gymnastic injury except in the low back.

In order to identify injury susceptibility in female competitive gymnasts, Steel and White<sup>33</sup> performed flexibility, hypermobility, spinal posture, and anthropometric measurements on forty competitive gymnasts. These athletes were compared to an injury score derived from the severity and extent of their previous gymnastic injuries. Results were analyzed between groups of "low" injury and "high" injury gymnasts (both groups had n=10). For nine of the variables a significant difference was demonstrated between these injury risk groups. The "high" group exhibited: increased height; weight; increased shoulder flexion, lumbar extension, and standing lumbar curvature; and an increased total periphery flexibility score obtained by the summation of all peripheral joint flexibility scores. Older athletes were also found to be more prone to injury. However, a nonsignificant relationship was discovered between hypermobility and musculoskeletal injury.

Conflicting and inconclusive information exists regarding the relationship between hypermobility and injury prediction. A clear link has been demonstrated in football but not in dancing or gymnastics. One explanation for this

discrepancy could be the argument over exactly what systemic joint hypermobility is and more importantly, how it is defined. The purpose of this study is two-fold: first, to study the prevalence of hypermobility in young competitive gymnasts, and secondly, to determine if the presence of hypermobility predisposes the athlete to particular joint pathologies.

## CHAPTER II

### METHODOLOGY

#### Subjects

Forty-four female members of the competitive gymnastics team from the American Gold Gymnastics Club in Fargo, ND, volunteered for this study. Subjects' age ranged from 4 to 16. Gymnasts were divided into three groups based on level classifications according to guidelines established by USA Gymnastics. The "Little Giants" group consisted of 14 girls, aged four to five years, who are classified as level 1 to 2. Seventeen gymnasts were members of the "Dynamites" group, which included girls aged five to nine years, and performing at level 6. Finally, the "elite" group was comprised of 13 athletes aged 8-16. Four of these gymnasts were at level 7, 5 at level 9, 2 at level 10, and two had achieved elite status.

According to these guidelines, levels 1-4 are labeled as testing levels in which there is no competition. Levels 5-7 compete at the compulsory level in which each gymnast learns and performs standard routines. Level 8 - elite athletes compete with optional routines which are rated by degrees of difficulty.

Little Giants practiced approximately two and one-half hours per week, while with Dynamites, practice time increased to six hours per week. The elites rehearsed between 17 and 21 hours per week.

Gymnasts presently having an acute injury to one of the joints being studied were excluded from this study. Informed consent documentation was read and signed by all legal guardians in accordance with standards set by the Institutional Review Board of the University of North Dakota (Appendix A).

#### Procedure

General joint mobility was assessed on each subject utilizing Beighton's revision of the Carter and Wilkinson system.<sup>1</sup> The gymnast received one point for every listed maneuver demonstrated, for a possible total of nine points. The maneuvers used in this scoring system were as follows:

- 1) Passive extension of the little finger beyond 90 degrees (1 point for each hand) - 2 points.\*
- 2) Passive opposition of the thumbs to the flexor aspects of the forearm (1 point for each thumb) - 2 points.
- 3) Hyperextension of the elbows beyond 10 degrees (1 point for each elbow) - 2 points.\*
- 4) Hyperextension of the knee beyond 10 degrees (1 point for each knee) - 2 points.\*
- 5) Forward flexion of the trunk with knees fully extended so that the palms of the hands rest flat on the floor - 1 point.

\*Measured with a standard goniometer according to guidelines established by Norkin and White.<sup>34</sup>

Subjects were considered hypermobile if they received a score of 6 or greater. This examination has been accepted by most clinicians as the standard for assessing joint hypermobility.<sup>1</sup> Although little information has been published concerning the reliability of the Beighton scale, one study has concluded its validity as compared to a 'global index' which was derived by using goniometry to assess the range of movement at almost all peripheral joints.<sup>1</sup>

The subjects also received range of motion assessments to complement the use of the hypermobility scale. Wrist extension was measured by a standard goniometer, due to the fact that forced wrist extension is common in gymnastic maneuvers and may result in an increased range of motion. Navicular drop was assessed through the use of a standard tape measure. This would indicate pronation of the foot, which can be a symptom of joint hypermobility. Measures of navicular drop are considered moderately (fair to good) reliable.<sup>35,36</sup> Lumbar extension was measured with the Back Range of Motion (BROM) device (Performance Attainment Associations, 958 Lydia Drive, Roseville, MN 55113). Many maneuvers undertaken by gymnasts demonstrate extremes in back extension. It is of the author's interest to see if lumbar extension may be related to hypermobility. Caution must be taken in examining these values since reliability and validity of the BROM have not been formally



reported. All measurements were taken before any warm-up or practice occurred to minimize the chance of a measurement being attributed to training and not genetic origin.<sup>31</sup>

The gymnasts were divided into two groups based on their hypermobility scores. Group 1 contained subjects scoring between 0-5 on the Beighton scale. Group 2 subjects scored a 6 or greater. All participants completed an injury reporting form with assistance from their parents. The form was developed by the author with input from Jraus and Berg<sup>37</sup> to review any past musculoskeletal injuries that the subjects may have experienced specifically involving the ankle, knee, lumbar spine, elbow, and wrist (Appendix B). The severity of each injury was also noted. This information was compared to and integrated with information from the athlete's medical release form, and injury documentation recorded by the training center.

### Data Analysis

Descriptive analysis was applied to determine the prevalence of hypermobility and the mean averages for the additional range of motion measures (wrist extension, lumbar extension, and navicular drop) in each subject group. An ANOVA and subsequent Tukey-B test were performed to determine significant differences between the three competitive groups. An independent t-test was utilized to compare the differences of the additional range of motion measures between hypermobile and non-hypermobile divisions. Lastly, a chi-square test was computed to determine a possible relationship

between the hypermobility scales and injury occurrence. All data were computed utilizing the SPSS-X program (Statistical Package for the Social Sciences).

## RESULTS

### Hypermobility Rate

Of the fourteen Little Giants evaluated, none were determined to be hypermobile. In contrast, 9 out of 17 (52.9%) subjects in the Dynamite group were classified as hypermobile. In the elite group, three out of thirteen gymnasts (23.1%) achieved a score of six or more on the Beighton scale (Table 1).

### Range of Motion

The mean range of motion for the three groups are listed in Table 2. An ANOVA and subsequent Tukey-B tests were applied to determine any significant differences between the ROM values between the three competitive groups. All of the differences were nonsignificant except left wrist extension and lumbar extension. The youngest group, the little Giants, demonstrated significantly greater left wrist extension ( $\alpha = .05$ ,  $df = 43$ ), while the oldest group, the Elites, demonstrated significantly increased lumbar extension ( $\alpha = .05$ ,  $df = 43$ ). When these means were subdivided into hypermobile and non-hypermobile divisions, an independent t-test demonstrated that the hypermobile elite athlete exhibited significantly greater right wrist extension ( $t = 2.69$ ,  $\alpha = .05$ ,  $df = 9.4$ ) than their non-hypermobile elite counterparts. This was not the case when analyzing right navicular drop, where the hypermobile

Table 1.--Percentages of Hypermobile and Non-hypermobile  
Gymnasts and Their Injuries by Groups

	Hyper	Mobile	Non-Hyper-	Mobile
TOTAL	# of Subjects	% of Total	# of Subjects	% of Total
Little Giants - 14	0	0	14	100.0
Dynamites - 17	9	52.9	8	47.1
Elite - 13	3	23.1	10	76.9

Table 2.--Mean Values for Range of Motion Measures by Groups  
as Determined Through Analysis of Variance

	Right Wrist Extension	Left Wrist Extension	Lumbar Extension	Right Navicular Drop	Left Navicular Drop
Little Giants n = 14	94.714 ( $\pm 2.946$ )	94.071** ( $\pm 2.895$ )	12.714 ( $\pm 3.361$ )	6.000 ( $\pm 2.253$ )	6.857 ( $\pm 2.476$ )
Dynamites n = 17	87.118 ( $\pm 10.816$ )	87.588 ( $\pm 7.985$ )	15.118 ( $\pm 4.299$ )	6.529 ( $\pm 2.853$ )	6.706 ( $\pm 3.197$ )
Elite n = 13	85.538 ( $\pm 13.030$ )	84.923 ( $\pm 11.586$ )	21.692** ( $\pm 6.588$ )	7.077 ( $\pm 1.977$ )	7.308 ( $\pm 1.932$ )
F-ratio	3.43	5.72*	12.38*	.66	.21
Df	43	43	43	43	43

( ) = standard deviation

\* significantly different at  $\alpha = .05$  as demonstrated by ANOVA test

\*\* significantly different at  $\alpha = .05$  as demonstrated by Tukey B test

elite gymnasts exhibited significantly less motion ( $t = -2.48$ ,  $\alpha = .05$ ,  $df = 11$ ). Otherwise, the differences between the hypermobile and non-hypermobile range of motion values were nonsignificant (Table 3).

#### Hypermobility and Injury Occurrence

The number of injuries for the specific joints studied are listed in Table 4. It is of interest to note that ankle injuries were by far the most common injury experienced compared to the other four areas. No significant difference was noted between the hypermobile and non-hypermobile divisions. Hypermobile Dynamites exhibited 1.11 injuries per subject, while the non-hypermobile Dynamites had .375 injuries per gymnast. This difference was not significant. The elite group, as a whole, demonstrated a significantly increased injury rate per subject (2.69) than the younger Dynamites (.765). However, the injury rate between hypermobile and non-hypermobile elites was nonsignificant (2.66 and 2.70, respectively).

Table 3.--Mean Values for Range of Motion Measures by Group and Divisions

	Hyper Mean	Non- hyper Mean	T- value	Df	Hyper Mean n = 9	Non- hyper Mean n = 8	T- value	Df	Hyper Mean n = 3	Non- hyper Mean n = 10	T- value	Df
Right Wrist Extension	N/A	N/A	--	--	90.00 (±12.44)	83.88 (±8.24)	1.18	15	94.67 (±1.16)	82.80 (±13.78)	2.69*	9.4
Left Wrist Extension	--	--	--	--	88.89 (±8.77)	86.13 (±7.30)	.70	15	93.67 (±4.04)	82.30 (±11.93)	1.58	11
Lumbar Extension	--	--	--	--	15.00 (±4.85)	15.25 (±3.92)	- .12	15	17.67 (±5.51)	22.90 (±6.64)	-1.23	11
Right Navicular Drop	--	--	--	--	6.44 (±2.79)	6.63 (±3.11)	- .13	15	5.00 (±1.73)	7.70 (±1.64)	-2.48*	11
Left Navicular Drop	--	--	--	--	6.00 (±2.50)	2.50 (±3.85)	- .96	15	7.00 (±3.61)	7.40 (±1.43)	- .19	2.19

N/A = non-applicable

( ) = standard deviation

\* significance at  $\alpha = .05$

Table 4.--Injury Occurrence per Division and Group

	Ankle/Foot	Knee	Low Back	Elbow	Wrist	TOTAL	Injury per Sub	T-value
Dynamite/ Hyper n = 9	7	1	0	1	1	10	1.11	
Non-hyper N = 8	1	1	1	0	0	3	.375	1.22
Total N = 17	8	2	1	1	1	13	.765	
Elite/Hyper n = 3	5	1	2	0	0	8	2.66	
Non-hyper N = 10	12	6	5	1	3	27	2.70	.03
Total N = 13	17	7	7	1	3	35	2.69*	

\* significance greater than dyno  $t = 6.64$ ,  $\alpha = .05$ ;  $df = 28$



## DISCUSSION

This research supports the findings of Kirby et al<sup>32</sup> and Steele and White<sup>33</sup> by failing to establish a relationship between injury and systemic hypermobility. The presence of hypermobility in the gymnasts studied was also greater than the percentages established in the general population by Carter and Wilkinson.<sup>8</sup> Of the 44 gymnasts evaluated, 12 were classified as hypermobile (27%), while Carter and Wilkinson stated that hypermobility is present in 5 to 7% of school children. The injury data collected support the notion that the ankle is the most frequently injured joint, followed by the knee, and lastly, the low back for the areas included in this study.<sup>16</sup>

The high incidence of increased left wrist extension in the Little Giants was not expected and may be a result of increased joint stability with age. This may occur due to strengthening of the forearm musculature secondary to the extreme forces placed upon it. This would not be the case for lumbar extension, where the increased movement occurring with age may be due to stretching of the stabilizing ligaments by repetition and attainment of extreme extension postures as may be seen in a back handspring or back walkover.<sup>16</sup> This increased lumbar extension may also shed some light into the reported high frequency of back injuries which occur in the sport of gymnasts. Kirby et

al<sup>32</sup> did establish a link between increased lumbar flexion and low back injury, although they failed to determine the same relationship in regard to increased lumbar extension.

The increased injury per subject ratio in the elites as compared to the Dynamites can be attributed to the elites greater number of years participating in the sport and their increased number of training hours per week as compared to the other groups. A study by Baxter-Jones, Maffulli, and Helms<sup>38</sup> found no significant associations between the number and severity of injuries and pubertal status with one exception. Female gymnasts in latter stages of puberty (stages 4 and 5) exhibited significantly more injuries than their younger counterparts.<sup>38</sup> The authors offer no explanation.

The cause of increased right wrist extension in the elite hypermobile gymnasts as compared to the elite non-hypermobile is unclear, as is the incidence of decreased right navicular drop. It is difficult to hypothesize why only the right side may be affected, though it may have a relationship to hand dominance and repetitive use. No previous research could be found to support such an association.

The limitations of this research include only studying five specific joints and the possible failure of parents/guardians surveyed to give objective and accurate information regarding the gymnast's injuries. The injury information provided by American Gold Gymnastics was also limited. The number of injuries reported in this study was small. A Chi-square test was attempted to

determine differences between frequency of injury between the specific joints studied. With the small number of reported injuries, a basic assumption of the Chi-square test was violated and the results could not be used.

The most significant, clinically relevant finding of this research is the increase in lumbar extension in the older, elite group. As mentioned earlier, this may be due to forced instability, which could account for the high incidence of back injuries among gymnasts. The use of strengthening exercises to the stabilization muscles of the back may provide a means to counteract this instability.

Further research is needed to elucidate the role of systemic hypermobility in the athletic and nonathletic population. What, if any, is its specific relationship to musculoskeletal pathology? Lastly, in an effort to provide better preventative care and avoid traumatic injuries in sport, we need to try elucidate specific characteristics in athletes that may predispose them to musculoskeletal injury.

## CONCLUSION

This evidence suggested that there is no relationship between systemic joint hypermobility and injuries to the ankle, knee, low back, elbow, or wrist. The data suggested that lumbar flexibility is significantly greater in the older, elite gymnasts than the younger Dynamites. While no relationship was shown between lumbar injuries and hypermobility in this study, a high incidence of back injuries in gymnastics has been reported and may be due to this increased range of motion.

## APPENDIX A

**UNIVERSITY OF NORTH DAKOTA'S  
INSTITUTIONAL REVIEW BOARD**

**DATE:** December 14, 1993

**NAME:** Jonathon M. Weiss **DEPARTMENT/COLLEGE** Physical Therapy

**PROJECT TITLE:** Hypermobility and Specific Joint Pathology in Young Competitive  
Gymnasts

The above referenced project was reviewed by the University's Institutional Review Board on 12/15/93 and the following action was taken:

- ☒ Project **approved**. Next scheduled review is on December 1994.  
If no date is given then review will be required in 12 months. (See REMARKS SECTION for any special condition.)
- ☐ Project approval **deferred**. (See REMARKS SECTION for further information.)
- ☐ Project **denied**. (See REMARKS SECTION for further information.)

**REMARKS:** Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairman or ORPD.

E. Simunds, Adviser  
Dean, Medical School

Elvira Azigeti 12/15/93  
Signature of Chairperson or designated IRB Member Date  
UND's Institutional Review Board

the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 596 Form may be required. Contact ORPD to obtain the required documents. (9/87)



# TEAM GOLD

## COMPETITIVE PROGRAM

American Gold Gymnastics  
2001 17th Ave. South  
Fargo, ND 58103 (701) 280-0400

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To: Institute Review Board

Fr: Marvin Sharp

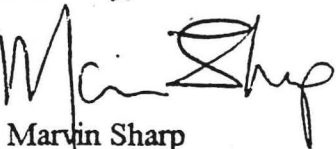
Re: Jon Weiss research study

Dear Sirs,

As Artistic Gymnastics grows into one of Americas most popular sports, it is good to discover that researchers have taken an added interest. There are not many studies available concluding the benefits and/or negative aspects of gymnastics training. As a head coach I am eager to have available any research information.

Following a meeting with Mr. Weiss and an overview of his goals and methodology, I am confident that his results will add to our knowledge of the sport and the athletes. Therefore we at American Gold Gymnastics and the "Team Gold" competitive team are willing to assist Mr. Weiss in his research. Team Gold will make available its facility and athletes in support of this study.

Sincerely,



Marvin Sharp  
Director/Head Coach

EXPEDITED REVIEW REQUESTED UNDER ITEM \_\_\_\_\_ (NUMBER[S]) OF HHS REGULATIONS  
 EXEMPT REVIEW REQUESTED UNDER ITEM \_\_\_\_\_ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA  
 HUMAN SUBJECTS REVIEW FORM  
 FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED  
 PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Jonathon M. Weiss TELEPHONE: 772-7054 DATE: Nov. 16, 1993  
 ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: 3904 University Ave. #22 Grand Forks, ND 58203  
 SCHOOL/COLLEGE: Graduate School DEPARTMENT: Physical Therapy PROPOSED PROJECT DATES: 1/93 - 3/93  
 PROJECT TITLE: Hypermobility and Specific Joint Pathology in Young Competitive Gymnasts

CONSULTING AGENCIES (IF APPLICABLE): N/A

TYPE OF PROJECT: ☐ NEW PROJECT ☐ CONTINUATION ☐ RENEWAL ☐ DISSERTATION OR THESIS RESEARCH ☒ STUDENT RESEARCH PROJECT  
☐ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Erin Simunds, MS, PT

PROPOSED PROJECT: ☐ INVOLVES NEW DRUGS (IND) ☐ INVOLVES NON-APPROVED USE OF DRUG ☐ INVOLVES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):

MINORS (<18 YEARS) ☐ PREGNANT WOMEN ☐ MENTALLY DISABLED ☐ FETUSES ☐ MENTALLY RETARDED  
 PRISONERS ☐ ABORTUSES ☐ UNDERSTUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ☐

ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.)

Children today are participating in organized athletics at earlier ages and in ever-increasing numbers. This is particularly evident in the field of gymnastics. The presence of joint hypermobility in the gymnastic athlete can be a considerable advantage, although the question has been raised whether this hypermobility may predispose the gymnast to musculoskeletal pathology.

Beighton's hypermobility scale and goniometric measurements will be used to assess hypermobility and flexibility in 45 female members (ages 5-14) of a competitive gymnastics club. Subjects will then be divided into two groups based on their hypermobility scores and surveyed for any past or current joint pathology specifically involving the feet, knees, lumbar spine, elbow and wrist. Statistical analysis will then be applied to determine if any relationship exists between the prevalence of systemic hypermobility and joint symptomatology.

The purpose of this study is to see if an assessment of joint hypermobility and flexibility should be considered to determine whether an increased risk for injury exists. Human subjects are necessary for this study as it is impossible to infer information on gymnastic injuries, and its relationship with hypermobility and flexibility, from any other source.



**EASE NOTE:** Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

**PROTOCOL:** (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

In this study, 45 female members of the competitive gymnastics team from the American Gold Gymnastics club in Fargo, ND, will be assessed for systemic joint hypermobility. The ages of these gymnasts range from 5 to 14 years old. Gymnasts presently having an acute injury to one of the joints being studied will be excluded from this project, due to the obvious skewed data that would result. Consent forms will be signed by subjects prior to initiation of the study with parental approval if subjects are under 18 years old.

Hypermobility assessments will be accomplished utilizing Beighton's revision of the Carter and Wilkinson system (1). The gymnast receives one point for every listed maneuver that they can demonstrate up to a total of nine points. The maneuvers used in this scoring system are as follows: 1) Passive dorsiflexion of the little finger beyond 90° (1 point for each hand) - 2 points; 2) Passive opposition of the thumbs to the flexor aspects of the forearm (1 point for each thumb) - 2 points; 3) Hyperextension of the elbows beyond 10° (1 point for each elbow) - 2 points; 4) Hyperextension of the knee beyond 10° (1 point for each knee) - 2 points; 5) Forward flexion of the trunk with knees fully extended so that the palms of the hands rest flat on the floor - 1 point (Appendix A). Patients are considered hypermobile if they receive a score of 6 or more out of 9. This examination has been accepted by most clinicians as the standard for assessing joint hypermobility (1). This test is easy to administer and can be completed within one minute. Although little information has been published concerning the reliability of the Beighton scale, one study has examined its validity. The Leeds group compared three different measures for assessing joint laxity. The first was the Beighton scale, the second was the Leed's hyperextensometer, and the third was a 'global index' derived by using goniometry to assess the range of movement at almost all joints. It was found that the Beighton scale correlated well with the global index, and with rapid assessment of the type required for studies, the Beighton scale was preferred (1).

The subjects will also be subjected to range of motion assessments to complement the use of the hypermobility scales. Little finger, knee, and elbow extension motions are components of the Beighton scale and will be measured according to the guidelines set by Norkin and White (2), as will wrist extension, which the author feels should be included as forced wrist extension is common in gymnastic maneuvers. Navicular drop will be assessed through the use a standard tape measure to indicate pronation of the foot, which can be a symptom of joint hypermobility. Measures of navicular drop are considered reliable as evidenced by Mueller, Host, and Norton (3). Lumbar extension will be measured utilizing the Back Range of Motion (BROM) device. Reliability and validity studies are pending. Wrist extension, lumbar extension and navicular drop will be considered separately from the hypermobility scales.

The gymnasts will then be divided into 2 groups based on their hypermobility scores. Group 1 will contain subjects scoring between 0-5 on the Beighton scale. While Group 2 subjects will have scored a 6 or greater. Both groups will complete the attached injury reporting form with assistance from their parents (Appendix B). This form reviews past musculoskeletal injuries the subjects may have experienced specifically involving the ankle, knee, lumbar spine, elbow, and wrist. These five areas are the most commonly injured during gymnastic maneuvers (4).

Once all forms are completed and returned, statistical analysis will be applied to determine the prevalence of hypermobility in this subject group. A Chi Square test will be administered to determine a relationship between the hypermobility scales and injury occurrence. Lastly, an independent t-Test will be utilized to compare the additional range of motion measures between each group.

- 1 Beighton P, Grahame R, Bird H. **Hypermobility of Joints**. New York, NY: Springer Verlag; 1983.
- 2 Norkin CC, White DJ. **Measurement of Joint Motion: A Guide to Goniometry**. Philadelphia, PA: F.A. Davis Company; 1985.
- 3 Mueller M, Host J, Norton B. Navicular drop as a composite measure of excessive pronation. J Am Pod Med Assoc. 1993; 83: 198-202.
- 4 Caine D, Cochrane B, Caine C, Zemper E. An epidemiologic investigation of injuries affecting young competitive female gymnasts. Am J Sports Med. 1989; 17: 811-20.

**BENEFITS:** (Describe the benefits to the individual or society.)

The possible benefits of this study are significant. If a relationship between systemic joint hypermobility and the potential for injury exists, steps may be taken to help avoid further damage to these athletes. The steps could include selective strengthening of stabilization muscles, advice on activity modification, or a biomechanical evaluation of joint alignment with the possible use of supports or orthotics.

**RISKS:** (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

There is very little chance that any subject will be injured by this experiment. The hypermobility scoring system is commonly used by most clinicians. The risk of injury occurring during this experiment are no greater than those present during a routine physical examination. These athletes currently participate regularly in this type of activity. The evaluation techniques do not even simulate the extreme movements commonly performed by gymnasts.

**CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

The consent forms will be kept in the University of North Dakota Physical Therapy Department in the Medical Science North building, room 146, for a period of 2 years.

For **FULL IRB REVIEW** forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development  
University of North Dakota  
Box 8138, University Station  
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

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policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

**SIGNATURES:**

Jonathan M. Wein  
Principal Investigator

Traci Simonds  
Principal Director or Student Adviser

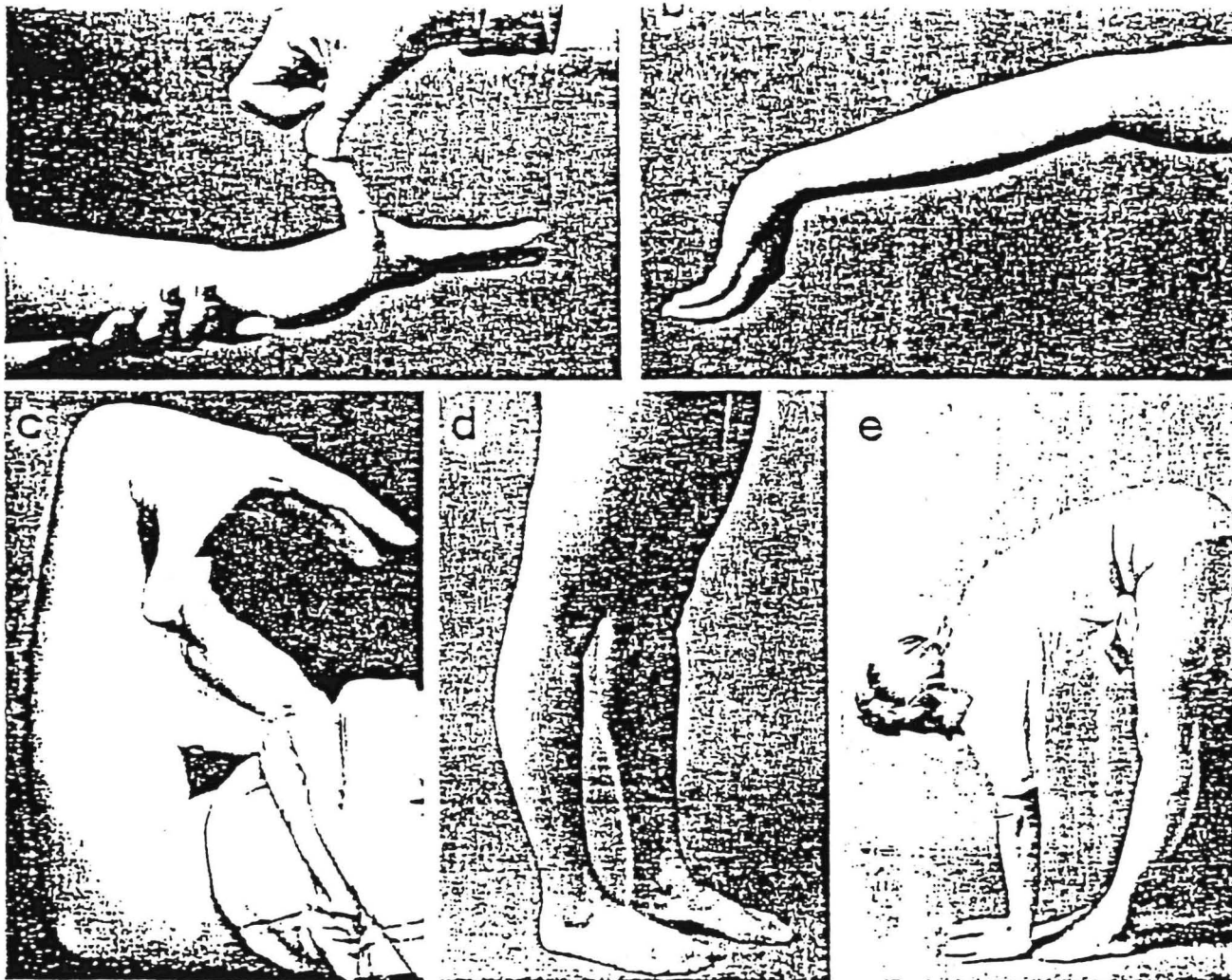
DATE: 12/9/93

DATE: 12/9/93

\_\_\_\_\_  
Principal or Center Grant Director

DATE: \_\_\_\_\_

## Appendix A



Manuevers used in the joint mobility score modified by Beighton.

Dear Parent/Guardian:

Greetings! My name is Jonathon Weiss and I am a graduate student in physical therapy at the University of North Dakota in Grand Forks. I am currently working on a research study entitled "Hypermobility and Specific Joint Pathology in Young Competitive Gymnasts," and I would like to invite your daughter to participate.

Joint hypermobility is simply a condition where the person can demonstrate an excessive range of movement at several joints. This is a natural, normal phenomena of hereditary origin that occurs in approximately 5-7% of all school-aged children. There have been a handful of authors who have suggested a relationship between hypermobility and an individual being prone to musculoskeletal injury. This research is designed to help answer this question.

The possible benefits of this study are significant. If a relationship between hypermobility and the potential for injury exists, several steps can be taken to help avoid any further damage to these athletes. These steps may involve strengthening, activity modification, or the possible use of supports. If your child is determined to be hypermobile, cessation of gymnastic activity would not be of particular benefit to your child, as it is very common for athletes to perform normally at their maximum capability while being hypermobile. Again, hypermobility is a natural occurrence affecting some people.

The attached consent form should answer any questions regarding the logistics of the study. Your child will undergo an approximate 10-minute flexibility evaluation that will take place during regular practice hours in January. There is no other time commitment required for you or your child except for filling out the attached survey. If you would like your child to participate, please sign the consent form, fill out the attached survey, and return the two sheets as soon as possible. These forms may be returned with your child to any Team Gold coach. If you would like a copy of the consent form, please indicate so on the bottom of the consent form and one will be sent to you.

This project has been approved by the Institutional Review Board at the University of North Dakota and has the full support of American Gold Gymnastics. If you have any questions, please do not hesitate to contact me at either (701) 772-7054 or (218) 253-2241 before January 10th or (701) 280-2212 after January 10th during regular business hours. I thank you in advance for your time and consideration and hope you and your child agree to participate in this study.

Sincerely,

Jonathon Weiss, SPT

acw  
Enc.



**Hypermobility and Specific Joint Pathology in Young Competitive Gymnasts.**

Weiss, Jonathon (University of North Dakota Department of Physical Therapy, Grand Forks, ND)

Investigator: Jonathon Weiss, SPT

Your child has been asked to participate in a study concerning the relationship between joint hypermobility and injury prediction in young competitive gymnasts. Your daughter will be evaluated for hypermobility utilizing the Carter and Wilkinson scoring system modified by Beighton. This system is routinely utilized by clinicians to evaluate joint hypermobility and consists of eight flexibility measurements. A survey will then be given for you and your child to fill out on any past injuries your child has experienced in gymnastics. This survey will then be returned to the investigator for analysis.

Participation is entirely voluntary and you and your child have the right to withdraw consent and/or discontinue participation in the study at any time without prejudice. The risks for this study are very minimal as the eight flexibility measurements are taken at a point where only mild stretching is experienced.

Information from this study will be anonymously coded and collected in aggregate to ensure confidentiality and your child will not be personally identified in any publication containing the results of this study. The investigator will be available to answer any questions you may have concerning the study, procedures, and any risks or benefits that may arise from participation in this study (701) 280-2212.

I have been satisfactorily informed of the above-described procedures with its possible risks. I know Jonathon Weiss, a graduate student at the University of North Dakota, will be available to answer any questions I may have. If I feel my questions have not been adequately answered, I may request to speak to Jonathon's academic advisor, Erin Simunds, MS, PT, at the University of North Dakota by calling (701) 777-2831. I understand that I am free to withdraw this consent and discontinue participation in this project at any time. I understand a copy of this consent form is available upon my request.

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Parent/Guardian

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Date

---

Child (when deemed appropriate by parent)

---

Date

## APPENDIX B



Name \_\_\_\_\_ Level of Competition \_\_\_\_\_

Age \_\_\_\_\_ Date of Birth \_\_\_\_\_

Months &amp; Years you have participated in gymnastics \_\_\_\_\_

Have you ever experienced one of the following injuries at or near any of the specific joints listed while participating in gymnastics? (Mark '1' if one episode occurred, '2' if two episodes occurred, . . .)

**ANKLE/FOOT    KNEE    LOW BACK    ELBOW    WRIST**

**OVERUSE INJURY**-irritation of the tissue, usually present with pain after activity, occurs non-traumatically

\_\_\_\_\_

**CONTUSION** (bruise)-soft tissue injury usually resulting from direct blow. Commonly discolored and tender

\_\_\_\_\_

**DISLOCATION**-displacement of bones from their normal position within the joint

\_\_\_\_\_

**FRACTURE**-a break in a bone

\_\_\_\_\_

**LIGAMENT SPRAIN** (mild)-stretch of a ligament resulting in less than one day loss of practice time

\_\_\_\_\_

**LIGAMENT SPRAIN** (moderate to severe)-stretch or tear of a ligament resulting in at least one day or more loss of practice time

\_\_\_\_\_

**MUSCLE STRAIN** (mild)-abnormal stretch of muscle resulting in less than one day loss of practice time

\_\_\_\_\_

**MUSCLE STRAIN** (moderate-severe)-abnormal stretch of muscle resulting in loss of at least one day or more of practice time

\_\_\_\_\_

Please briefly describe any injury listed previously:

Were any of the above reinjuries of a previous injury?

Did more than one of these injuries occur at the same time?

What side of the body was injured (right or left)?

What happened following the injury (or injuries)?

\_\_\_\_\_ Hospitalization

\_\_\_\_\_ Injury with no participation

\_\_\_\_\_ Injury with modified participation

\_\_\_\_\_ Injury with full-active participation

Additional comments you would like to share:

Thank you for your time and for participating in this study.

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